

REMARKS

Rejections under 35 U.S.C. §102(b)

The Examiner has withdrawn the rejection over Nakayama et al.; however newly rejects claims 1-8, 10-20 and 22-24 under 35 U.S.C. §102(b) as being anticipated by Sato et al. The Examiner alleges that Sato et al. teach a device having a substrate of an inorganic dielectric charge transfer material which forms a charge transfer complex with an organic semiconductor, wherein the charge transfer material comprises donors or acceptors; forms a self-assembling layer and is bonded to a substrate. The Examiner further alleges that Sato et al. teaches two thin film layers with one being a donor and the other being an acceptor, where charge transfer occurs between the layers. Applicants traverse this rejection and withdrawal thereof is respectfully requested.

The present invention, as encompassed by claim 1, is drawn to a device for electrical contacting or for the isolation of organic or inorganic semiconductors in electronic or optoelectric devices comprising

a substrate, either in the form of

- a) a contact material consisting of an organic or inorganic electrical conductor, or
- b) an isolating material consisting of an organic or inorganic dielectric; and

a patterned or unpatterned charge transfer material, which is on or at a surface of the substrate and which forms a charge

transfer complex with an organic or inorganic semiconductor,

wherein the charge transfer material

- a) comprises charge transfer components in the form of donors or acceptors,
- b) forms a self-assembling layer of one or more atomic and/or molecular layers,
- c) has a direct or indirect bond to the surface of the substrate, and
- d) forms a donor material in the charge transfer complex if the semiconductor is an acceptor or forms an acceptor material in the charge transfer complex if the semiconductor is a donor material.

As discussed by the Examiner, Sato et al. teaches a device having a substrate of an inorganic dielectric. The device of Figure 1 of Sato et al. is specifically a display device where a transparent electrode (2) is provided on a glass substrate (1), with the electrode being, for instance, made of a metal oxide.

The electrode (2), has a first organic thin film (3), which contains acceptor molecules and a second organic thin film (4), which contains donor molecules, wherein (3) and (4) are alternately formed to produce a laminate. Finally a gold electrode (5) is provided on top of the laminate of (3) and (4). The acceptor and donor molecular films (3) and (4), are based on molecules having tetracyanoquinodimethane (TCNQ) and tetrathiafulvalene (TTF), respectively. Prior to Sato et al. it

had been previously proposed in the field to use TCNQ and TTF as acceptors and donors, but it turned out to be very difficult to synthesize the molecules and orient them in a suitable state.

It was then found that by preparing donor and acceptor molecules in separate solutions and using a Langmuir-Blodgett process to form a laminate film by stacking the different monomolecular films, it was possible to create alternating acceptor and donor molecular films having excellent performance in controlling charge transfer between donor molecules and acceptor molecules using external energy such as voltage or light radiation. However, the energy input needed to obtain a normal operation with this set-up was unacceptably large. The object of Sato et al. was to address these problems and to provide an organic thin film having a small threshold value of an external potential and hence being capable of providing an operative performance that only requires a small external energy.

The device of Sato is made of a stack of organic thin-films of alternating acceptor and donor molecules. In Sato et al., the second organic thin-film has a dipole moment P_1 with a center produced by charge transfer between the acceptor and donor molecules, and at least one of the first and second organic thin-films includes a chemical species with the dipole moment P_2 , with the center such that dipole moment vectors are produced by a charge transfer between the acceptor or donor molecules that satisfy a certain formula. The chemical species in Sato et al. with the aipole moment P_2 has a conjugated hydrocarbon skeleton

linked to a donor having an electron-attracting substituent of a nitro, cyano, carbonyl or sulphonyl group, and a donor molecule having an electron-donating substituent of an amino, alkoxy, or hydroxy group.

As evidenced from an overall reading of Sato et al. and, for example, in the embodiments of column 2, it is evident that the device of Sato et al. is very different from that of the present invention. The Sato et al. device is an organic thin-film device containing donor and acceptor molecules, such that the application of an external energy in the form of an electric field, voltage, or light results in charge transfer between at least a part of the donor/acceptor molecules inside the organic thin film. This charge transfer causes a change in absorption spectra or conductivity of the film creating a dipole moment in the film and hence functional devices such as display devices, rectifiers, switching devices etc. may be created.

In contrast with Sato et al., the present invention is drawn to a means for electrical contacting or isolation of organic or inorganic semiconductors in electronic and optoelectronic devices. The present invention overcomes the problem of the high resistivity of semiconductor materials that can make current injection at the contacts problematic. The specifically stated object of the present invention is to provide improved contacts for contacting organic, as well as inorganic semiconductors, in electronic and optoelectronic devices, particularly thin-film devices, or to provide isolation of organic or inorganic

semiconductors in electronic or optoelectronic devices, for instance to reduce or eliminate leakage currents outside an active area in an electronic semiconductor or to reduce the effective channel length in organic or inorganic field-effect transistors realized in thin-film technology.

To this end, the present claims recite using a charge transfer material that includes charge transfer components in the form of donor and/or acceptors, forms a self-assembling layer of one or more atomic and molecular layers, and bonds directly or indirectly to the surface of the substrate. The charge transfer material forms a charge transfer complex together with an adjacently provided organic or inorganic semiconductor. The charge transfer complex is formed if the charge transfer material is a donor and the semiconductor an acceptor or if the charge transfer material is a donor and the semiconductor material an acceptor. The charge transfer material according to the present invention also could be a mix of acceptor and donor molecules. In one aspect of the present invention it is important to provide a charge transfer material that forms a bond with the substrate, in contrast with prior art materials where stability has turned out to be a problem.

The present invention recites the use of inorganic as well as organic charge transfer materials that may be capable of furnishing the required donor or acceptor function, and are further able to form a direct or indirect bond to a substrate surface. It should be noted that the charge transfer material can

also be a mixture of both donor and acceptor molecules and the charge transfer complex as formed will be dependent on whether the semiconductor material is an acceptor or donor material. Acceptor/acceptor or donor/donor combinations provide the isolating function of the invention.

None of the above discussed aspects of the invention are relevant to Sato et al. and in contrast Sato et al., the charge transfer material of the present invention does not furnish the specific functionality of the device, but rather serves to either improve the contact properties between the injecting electrodes or to isolate the structures in the semiconductor outside the active area to reduce, for example, leakage and loss. The devices of Sato et al. are passive display devices that exhibit various colors, depending on the voltage applied, when illuminated with light. In other words the devices of Sato et al. are analogous to LCD devices.

In contrast with Sato et al., the present invention is drawn to the use of charge transfer materials to enhance the current injection efficiency or conversely to provide isolation in active semiconductor devices, such as field effect transistors or light-emitting devices. The device of the present invention cannot be compared to Sato et al., which only provides a passive organic thin-film device with alternating organic thin films with acceptor and donor molecules and at least one thin film containing a chemical species with a dipole moment given by some chemical species, such that the dipole moment produced by charge

transfer between acceptor or donor molecules satisfies a formula that gives a special positional relationship between dipole moments P1 and P2. These properties of Sato et al. are necessary for the device of the reference to function as a passive display device.

Fig. 1 of the present specification schematically depicts a charge transfer molecule (2) bound to the substrate (1) over a functional head group (2') and forming a chemical bond (2'') with a substrate. Figs. 3 and 4 of the specification show how the present invention is used to improve the charge injecting properties of a field effect transistor and it shown that the charge transfer material (3) is provided between a semiconductor (6) and the source and drain contacts (1a). Fig. 5 is a light-emitting diode wherein a layer of charge transfer material (3) is provided between the semiconductor (6) and respectively the cathode (7) and the anode (8). While, the device of Figure 5 may superficially resemble the device of Figure 1 of Sato et al., the semiconductor (6) of Figure 5, has no counterpart in the device of Figure 1 of Sato et al. The dipolar properties of the device, which are essential to Sato et al., are of no issue of the present invention.

In other words, the Examiner's assertion that Sato et al. teaches a charge transfer material, specifically a charge transfer complex with an organic semiconductor is not correct. Sato et al. fails to disclose an active semiconductor as with the present invention, and the device of Sato et al. is not capable

of furnishing active semiconductor devices, e.g. a field-effect transistor or a light-emitting diode.

The differences between Sato et al. and the present invention are evidenced from the preferred embodiments described in column 4, lines 49-65 of Sato et al. The disclosure of Sato et al. teaches that preferred embodiments include a chemical species with a dipole moment and that the chemical species may include a pigment; i.e. a functional group, such as a chromophore bonded to the donor or acceptor molecule; that the thin films are alternately laminated to form a superlattice; and the presence of hydrophilic groups on the bottom ends of a segment skeleton of at least one of a donor and an acceptor skeleton.

In summary, Sato et al. only shows a passive device having alternating laminated and stacked layers of acceptor and donor molecules and having a chemical species to obtain a voltage controlled dipole moment, thereby being able to provide a purely passive color display device. The device according to Sato et al. does not comprise an active semiconductor in the sense of the present invention. As such, Sato et al. is not able to furnish an active semiconductor device of the kind disclosed in the present invention, for instance as a field-effect transistor or a light-emitting device. The function of the charge injecting material in the present invention is to improve the charge injection efficiency or the contact properties or provide isolating properties as applicable in such active thin-film devices. These considerations are irrelevant to Sato et al.

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As such, the present invention is not anticipated by Sato et al. and withdrawal of the rejection is respectfully requested.

As the above-indicated remarks address and overcome the objections and rejections of the Examiner, withdrawal of the objections and rejections and allowance of the claims is respectfully requested.

Should the Examiner have any questions, regarding the present application, he is requested to please contact, MaryAnne Armstrong, PhD (Reg. No. 40,069) in the Washington DC area at (703) 205-8000.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

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